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UNITED STATES PATENT APPLICATION
FOR

METHOD, COMPUTER PROGRAM PRODUCT AND SYSTEM FOR PROVIDING A
SWITCH USER FUNCTIONALITY IN AN INFORMATION TECHNOLOGICAL
NETWORK

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Patent 20010013

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2 FIELD OF THE INVENTION
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4 The present invention relates generally to server-agent environments, and
5 more particularly to a method, a computer program product and a system for
6 providing a switch user functionality in such an environment.
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8 BACKGROUND OF THE INVENTION
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10 Nowadays, as information systems become ubiquitous, and companies and
11 organizations of all sectors become dependent on their computing resources, the
12 requirement for the availability of the hardware components and software
13 components (applications) of an IT network and of services based on it,
14 (hereinafter all three are generally referred to as "objects") is increasing while
15 the complexity of IT networks is growing.

16 There are network management systems available which enable the
17 availability and performance of objects within an IT network to be monitored and
18 managed. For example, Hewlett-Packard offers such network monitoring and
19 managing tool, which is a server-based, under the name "OpenView". The
20 product is available for Windows and Unix operating systems. It comprises a
21 management server, a user interface to operate the server and several "agents"
22 for different operating-system platforms. An agent is a program or process
23 which runs on a managed node. A personal computer, network node (in the
24 narrow sense) or any system with a CPU is called a node. A managed node is a
25 node which is monitored and/or managed by the management system.

26 In order to allow the users of such a system to react to network problems,
27 the agents implement a feature which enables software tools or applications to
28 be started remotely. For example, if the operator of the system detects a
29 possible problem on the monitored node, he can, via the management server and

1 using the user interface, initiate the start of a software tool on the monitored
2 node which carries out diagnosis, recovery, repair and/or reconfiguration
3 actions.

4 Often, such a tool must be started using a different user account than the
5 account of the operator. To achieve this, the agent has a built-in "switch user"
6 functionality which allows the operator to change his account to the user
7 account which is needed. To use this functionality on Windows NT systems, the
8 agent calls a Windows NT application programming interface (API) in a particular
9 way which is not transparent for normal users, e.g. by including a certain code
10 which is generated by the agent software independent and is independent from
11 the account to which the switch user is to be performed. The call will be
12 forwarded to the Windows NT domain controller. A sub-authentication
13 component (a dynamic link library (DLL) component), which extends the
14 standard Windows NT user name and password authentication component on
15 the domain controller, will receive that call and verify that the call has been
16 performed in the correct way, e.g. by checking the code word (the standard
17 Windows NT authentication component is, for example, described in Microsoft
18 Windows 2000 Security Technical Reference, Redmond, 2000, pages 22-23 and
19 154-155). If the check reveals that the call has been made correctly, it will allow
20 the agent to perform the switch user to the requested account. The password of
21 the account is not needed by the agent or the domain controller to perform the
22 user switch.

23 24 SUMMARY OF THE INVENTION

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26 The invention provides a method for providing a switch user functionality in
27 a server-agent environment in an information technological (IT) network. At least
28 one agent runs on a node of the IT network. The method comprises the
29 following steps: generating a switch user (SU) certificate using public-key

1 cryptography upon receiving a request to switch from a user account presently
2 used on the node to another user account; sending the SU certificate to the
3 agent; checking the correctness of the SU certificate; performing the requested
4 switch to the user account provided that the SU certificate is correct.

5 According to another aspect, the invention provides a computer program
6 product including program code for providing a switch user functionality in a
7 server-agent environment in an information technological (IT) network, in which
8 at least one agent runs on a node of the IT network. Said program code is for:
9 generating a switch user (SU) certificate using public-key cryptography upon
10 receiving a request to switch from a user account presently used on the node to
11 another user account; sending the SU certificate to the agent; checking the
12 correctness of the SU certificate; performing the requested switch to the user
13 account provided that the SU certificate is correct.

14 According to still another aspect, the invention is directed to a system for
15 managing objects in an information technological (IT) network having a network
16 management server and at least one management agent which runs on a
17 managed node of the IT network. The system provides a switch user
18 functionality. It comprises: an SU certificate generation component which uses
19 public-key cryptography; an SU certificate sending component which sends the
20 certificate to the agent; an SU certificate checking component; a user account
21 switching component performing the requested switch provided that the SU
22 certificate is correct.

23 Other features are inherent in the system, computer program product and
24 method disclosed or will become apparent to those skilled in the art from the
25 following detailed description of embodiments and its accompanying drawings.

27 DESCRIPTION OF THE DRAWINGS

28
29 In the accompanying drawings:

Fig. 1 shows a high-level architecture diagram of an object managing system which provides a switch user functionality;

Fig. 2 illustrates the generation and checking of an SU certificate according to a first embodiment;

Fig. 3 illustrates the generation and checking of an SU certificate according to a second embodiment;

Fig. 4 is a flow chart of a switch user certificate method using the generation and checking method of fig. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 shows a high-level architecture diagram of a preferred embodiment. Before proceeding further with the description, however, a few items of the preferred embodiments will be discussed.

In the preferred embodiments, a switch user functionality is provided in a server-agent environment in an IT network, such as a computer network or a telecommunication network. A node is a network object such as a PC, network node (in the narrow sense) or any system with a CPU. An agent is a program or process running remotely on a node. For example, an agent may be able to respond to requests from the server relating to the node or an application residing on it, perform operations and/or send notifications to the server relating to the node or the application.

In the preferred embodiments, the server-agent environment is a network management environment which enables monitoring and management of nodes of the IT network, which are called "managed nodes". The object to be managed and monitored may be the managed node, an application (or part of an application) running on it or a hardware resource needed by the application (such as a storage disk). The monitoring may comprise passive monitoring (e.g. collecting error messages produced by the objects) or active monitoring (e.g. by

1 periodically sending a request to the object and checking whether it responds
2 and, if applicable, analyzing the contents of the response). Management tasks
3 may be, for example, diagnosis tasks, error correcting or fixing tasks, setting
4 tasks or other network services.

5 In the preferred embodiments, the server of the server-agent environment is
6 a management server which controls, administers, records, analyses and/or
7 displays the management activities and events. The agents are management
8 agents which respond to monitoring or management requests, perform the
9 actual monitoring or management operations and/or send event notifications.

10 It has been recognized by the inventor of the present invention that, in the
11 prior art mentioned at the outset, the agent software is in a relatively insecure
12 environment since it is distributed over several or all managed nodes in a
13 network domain (which can involve a whole network). Therefore, an agent could
14 be target of "reverse engineering". It cannot be excluded that a malicious user
15 could intercept a switch user call and find out how the agent is able to perform
16 the switch user and to simulate the behavior with a self-written program.

17 In order to exclude such possible attacks, in the preferred embodiments a
18 switch user (SU) certificate is generated when a switch user request is received,
19 using public-key cryptography.

20 In the preferred embodiments, the SU certificate is generated by the
21 management server, which sends it to the agent. The agent, in turn, forwards
22 the received SU certificate to a domain controller which carries out the check of
23 the correctness of the SU certificate and allows the agent to perform the
24 requested switch user. The management server and domain controllers are
25 normally in a secure environment and can be seen as save.

26 In the preferred embodiments, the SU certificate is generated with a digital
27 signature public-key algorithm, such as RSA or DSA. Digital signatures and
28 public-key algorithms are, for example, described in B. Schneier: "Applied
29 Cryptography, 2nd edition, 1996, pages 34-41, 461-474 and 483-494.

1 In the preferred embodiments, a private and public key pair is available
2 before the SU certificate is generated. For example, the key pair can be
3 generated during the set-up of the management system. A renewal of the key
4 pair can be performed manually or automatically from time to time. Recent
5 operating systems support key generation; for example, an RSA key can be
6 generated using the Windows NT Crypto API.

7 In the preferred embodiments, the public key is made public for
8 "everybody" (i.e. every node and process) within the network or a domain of the
9 network in which the check of the correctness of the SU certificate is
10 performed. The publication of the public key can be realized by storing the public
11 key such that it can be accessed from all the nodes in the network or domain
12 but cannot be modified by them; only the component which generates the key
13 pair (e.g. the management server) can modify this information. For example, the
14 Windows 2000 Active Directory already provides this infrastructure so that the
15 above-described public key publication can easily be implemented in Windows
16 2000 domains using the Active Directory (see Windows 2000 Security Technical
17 Reference, pages 89-151).

18 The generation of the SU certificate comprises signing an SU document
19 with the private key. The check of the SU certificate comprises verifying the
20 signature with the public key. There are many public-key digital signature
21 algorithms with different implementations (see Schneier, pages 39 and 461-
22 502). In the most common algorithm, RSA, the signing process is called
23 encrypting with a private key and the verification process is called decrypting
24 with a public-key. The verification comprises checking the authenticity and
25 integrity of the transmitted SU certificate. In other words, it is verified that the
26 SU certificate originates from the management server and that it has not been
27 modified in transit.

28 Apart from choosing a particular public-key algorithm, there are different
29 possible ways to actually generate a signature. When, for example, RSA is used,

1 the plaintext SU document (or that part of it which has to be secured) is
2 encrypted with the public key, and the resulting ciphertext represents the
3 signature. In order to verify the signature, it is decrypted with the public key.
4 For the verification, it is sufficient that the resulting decrypting text is
5 meaningful, since it is a feature of the used strong encryption algorithms that a
6 decryption with a wrong public key or any modification of the signature would
7 result in a completely different plaintext with generally no meaning. It is likewise
8 possible to explicitly check whether the result of the decryption is identical with
9 the original plaintext SU document, which, for example, can be transmitted
10 together with the signature and form part of the SU certificate.

11 Since the signing process using the whole (plain) data is generally time
12 consuming, by preference another possibility is chosen. A relatively unique
13 representation (also called a "fingerprint" or "message digest") of the data (i.e.
14 the SU document) is first generated using a process in which the data is
15 "condensed" or "hashed", for example by means of a message digest function
16 (e.g. a one-way hash function) into a value of relatively small length, thereby
17 fixing its contents, and the signing process is performed on the fingerprint,
18 resulting in an equivalent effective authentication. Therefore, the term digital
19 signature herein refers to the digital signature of either the plain data element(s)
20 or of any representation (function) thereof. According to this second possibility,
21 the transmitted SU certificate is composed of the original SU document in
22 plaintext and, in addition, the fingerprint of this document, encrypted with the
23 private key. To verify an SU certificate, the plaintext part of the certificate is
24 condensed by means of the same message digest function (e.g. the one-way
25 hash function) and the resulting message digest (hash) value is compared with
26 the fingerprint decrypted with the public key. If these values are equal, the
27 authenticity and integrity of the SU certificate is verified. Since the plaintext is
28 generally bigger than the message digest, the message digest does not uniquely
29 specify the plaintext - it is possible for many plaintexts to have the same

1 message digest. However, the message digest has the following characteristics
2 which makes it useful: i) A message digest is one-way, in the sense that, given
3 a specific message digest, it is computationally unfeasible to find a plaintext
4 with that message digest. Thus, the correspondence between a given message
5 digest and a given plaintext can be verified, but the plaintext cannot be
6 recovered from the message digest. ii) It is computationally unfeasible to find
7 two messages with the same message digest. Thus, in practical terms, if a
8 message digest is verified for a given message, it can be assumed that it was
9 generated from that message. As a result of these two properties, the message
10 digest can be relied upon as a concise summary of the plaintext, and it can be
11 substituted for the plaintext in the digital signature algorithm. Suitable message
12 digest functions are, for example, MD5 and MD4 (see Schneier, pages 429-
13 459).

14 In the preferred embodiments, the SU certificate comprises the account
15 name to which the account is to be switched and an identification of the node
16 for which the switch is to be performed. The account name and the
17 identification are secured by the signature. In the checking step it is verified that
18 the node identification actually corresponds to the node to which the switch
19 user request is directed. This ensures that a certificate may not be used by an
20 attacker for another node.

21 Preferably, the SU certificate contains no password specific for the account
22 to which the switch is to be performed. This is because a password-
23 identification system would require reasonable administrative effort because all
24 password changes in the network would have to be followed by all network
25 nodes. In addition, if the password were transmitted with the SU request, an
26 attacker might be able to catch and decrypt it and use it for malicious purposes.
27 The password-less switch user functionality of the preferred embodiments
28 requires little administrative effort and is secure due to the use of the described
29 switch user certificates.

1 In order to avoid what is called replay attacks, the SU certificate should
2 also preferably comprise a time stamp and/or another certificate identification
3 stamp. For example, the time stamp indicates the point of time of the
4 certificate's generation. When the certificate is checked, it is then also verified
5 that the certificate is not outdated and/or has not been used before by means of
6 the time stamp or the certificate identification stamp. For example, if the
7 "lifetime" of a certificate is defined to be five minutes, the certificate older than
8 this lifetime would be rejected in the check. A certificate which is younger than
9 the lifetime will pass this check, however, an additional check is performed as to
10 whether the certificate has already been used by a different request. To this
11 end, the component which is responsible for the check stores data (for example,
12 the certificate identification stamp) of all certificates from the last five minutes.
13 By comparing the present certificate data with all stored ones, it can find out
14 that a certificate has already been used, and will then deny the switch user
15 request. If the present request passes all the checks successfully, the certificate
16 checking component will store the present certificate's data and will remove all
17 stored certificate data which is older than the lifetime. Then it will allow that the
18 switch user is performed.

19 The preferred embodiments of the computer program product comprise
20 digital program code which, for example, is stored on a computer-readable data
21 carrier or is in the form of signals transmitted over a computer network. The
22 preferred embodiments of the program code are written in an object-oriented
23 programming language (e.g. Java or C++). The program code can be loaded (if
24 needed, after compilation) and executed in a computer or in networked
25 computers, e.g. a management server network with managed nodes.

26 Returning now to Fig. 1, it shows a high level architecture diagram of a
27 preferred embodiment of an object management system 1 which provides a
28 switch user (SU) functionality. The system 1 is part of a network 2 which
29 comprises a domain controller 3 and nodes 4, one of which is shown in Fig. 1. A

1 domain constitutes an administrative and security boundary within a network. A
2 domain controller provides domain-related administrative and security services to
3 the network nodes and users. For example, it stores domain-wide directory data
4 (such as the system security policy) and manages user domain interactions,
5 including user-login, authentication and directory searches (see Microsoft
6 Windows 2000 Security, pages 5 and 95).

7 The node 4 is monitored and managed by the object management system
8 1, and is thus called a "managed node". An application 5 which is monitored by
9 the management system 1 runs on the managed node 4. The monitored
10 application 5 can be part of a complex application (for example, an SAP
11 application) which may be distributed over several nodes. An agent 6 monitors
12 the application 5. The agent 6 is a program running on a remote device (here the
13 node 4) that responds to monitoring or management requests from a
14 management server 7, performs monitoring and management operations
15 regarding the monitored application 5 and the managed node 4, and/or sends
16 event notification to the management server 7. In other preferred embodiments,
17 the agent runs on a remote or external node which is different from the node
18 which hosts the monitored application. If they are several applications to be
19 monitored on one managed node, they will be preferably monitored by one and
20 the same agent. Although there is normally one agent per managed node, in
21 other embodiments one agent can manage several nodes. The agent 6 is
22 configured by a set of specifications and rules, called policy for each application
23 5 to be monitored. A policy tells the agent what to look for and what to do
24 when an event occurs. For example, according to a particular policy an agent
25 filters events and generates messages which inform the management server 7
26 about the occurrence of certain events and/or the status and performance of the
27 monitored application 5. The agent 6 also implements a feature to start tools or
28 applications on the managed node 4 from the management server 7. These may
29 be, for example, diagnosis tasks, error correcting or fixing tasks or setting tasks.

1 The management server 7 provides centralized management services,
2 processes and/or a management user interface 8 to the management operator
3 and other users. In particular, the management server 7 collects events and
4 performance data from the agent 6, processes them and roots the results to a
5 monitoring console (for example, the user interface 8). The management server
6 7 also centrally deploys deployment packages, agents and policies, as directed
7 by the user, and stores definitions and other key parameters. The remote
8 management tools and applications mentioned above are also started by a user
9 via the user interface 8 and the management server 7.

10 During the set-up of the operating system or the management system, a
11 private and public key pair is generated by the management server 7 using the
12 Windows NT Crypto API. The management server keeps the private key secret
13 and publishes the public key using the domain controller's Windows Active
14 Directory, which is designated as public key publication component 9 in Fig. 1.
15 If the management system operator wants to start a tool on the managed node
16 4 which requires a switch to another account he is currently using, he initiates
17 the call to the corresponding tool and the request to switch to the other
18 account, without providing the password of the account, via the user interface
19 8. When the management server 7 gets the request, it generates an SU
20 certificate by means of a certificate generation component 10, using the private
21 key. The SU certificate 11 is sent by means of a sending component 12 to the
22 managed node 4 together with a usual call to start the tool under the requested
23 account. The agent 6 receives the call and forwards the certificate to the
24 domain controller 3 by calling the Windows NT API. The domain controller 3
25 comprises a DLL component which is designated as the certificate checking
26 component 13 in Fig. 1. It is specifically adapted to the management server
27 system 1 in order to allow a switch to another user account without a
28 password. The DLL component 13 checks the certificate 11 using the public key
29 of the management server 7 which is published by the public key publication

1 component 9. If the check reveals that the SU request is acceptable, the DLL
2 component 13 authorizes the switch user by returning an SU token 14 to the
3 agent 6. In turn, an account switching component 15 of the agent 6 performs
4 the switch to the requested other user account, and the agent 6 performs the
5 tool, according to the request sent by the management server 7.

6 The generation and checking of an SU certificate according to a first
7 embodiment is illustrated in Fig. 2. At first, the plaintext SU document 21 is
8 generated which contains switch user identification data. In the shown
9 embodiment, it contains five such data: A certificate identifier, the name of the
10 management server, the name of the managed node on which the switch user is
11 to be performed, the name of the account to which the switch user is to be
12 performed, and a time stamp. The SU document 21 is then encrypted with the
13 management server's private key 22. The resulting ciphertext 11' of the SU
14 document 21 is a what is called a digital signature of the SU document 21 and
15 can be used as the certificate 11 in Fig. 1. The certificate 11' is then transmitted
16 to the node 4 on which the switch user is to be performed and is forwarded to
17 the DLL component 13 of the domain controller 3. The DLL component 13
18 decrypts the certificate 11' using the public key 23, and thus obtains a
19 decrypted SU certificate 24. If the SU certificate 11' has not been modified
20 during transmission and has been decrypted with the correct public key (i. e. the
21 management server's public key), the decrypted SU certificate 24 is identical
22 with the original plaintext SU document 21. The subsequent step of checking is
23 carried out using the decrypted SU certificate 24. In particular, it is checked
24 whether the contents of the decrypted SU certificate 24 is meaningful (for
25 example, if it contains the correct name of the management server). If this is the
26 case, the authenticity and integrity of the SU certificate 11' is proven.
27 Alternatively, it can be checked whether the decrypted SU certificate 24 is
28 identical with the plaintext SU document 21 (which may be transmitted together
29 with the SU certificate 11') in order to verify authenticity and integrity.

Furthermore, it is checked whether the name of the node indicated in the decrypted SU certificate 24 corresponds to the node 4 for which the switch user is requested. Further, it is checked whether the certificate is still within its lifetime, i. e. whether the time indicated in the time stamp of the decrypted SU certificate 24 does not indicate a time which lies more than the predetermined lifetime (e.g. 5 min) in the past. Finally, if the certificate is still within its lifetime, it is checked whether the certificate has been used before, for example by comparing the certificate identifier of the decrypted SU certificate 24 with stored identifiers of those SU certificates which have been processed in the past within the certificate's lifetime (e.g. within the last 5 min). The certificate identifier is optional: In other embodiments, there is no certificate identifier, and another data (for example the time stamp) is used for the comparison. If all these checks reveal that the certificate is authentic, has not been modified, corresponds to the correct node, is not outdated and has not been used before, the requested switch user is accepted, and, therefore, initiated.

Fig. 3 illustrates the generation and checking of an SU certificate according to a second embodiment. As with the first embodiment, the first step is the generation of the plaintext SU document 21. It contains the same switch user identification data as the SU document 21 described in connection with Fig. 2. Different from the embodiment of Fig. 2, a message digest function MD is applied to the SU document 21, resulting in a fingerprint 25 of the SU document 21, which has a reduced length (for example 128 bits). Then, instead of the SU document 21, only its fingerprint 25 is encrypted with the private key 22. The encrypted fingerprint constitutes a digital signature 26 of the SU document 21 according to the second embodiment. The signature 26 is then combined with the plaintext SU document 21. Their combination forms the certificate 11' according to the second embodiment, which can be used as the certificate 11 in Fig. 1. The certificate 11' is then transmitted to the node 4 and forwarded to the DLL component 13 of the domain controller 3, as with Fig. 2. The DLL

1 component 13 decrypts the signature 26 with the public key 23, which reveals
2 the decrypted signature 27. If the correct public key has been used and the
3 signature 26 has not been modified, the decryption of the signature 26 reveals
4 the original fingerprint 25. Further, the DLL component 13 generates a message
5 digest 28 of the plaintext SU document part of the certificate 11''. The
6 decrypted signature 27 and the message digest 28 of the plaintext part of the
7 certificate 11'' are then compared. If they are identical, the authenticity and
8 integrity of the certificate 11'' is verified since any modification of the plaintext
9 part of the certificate 11'' would result in a different message digest 28 and a
10 decryption of the signature 26 with a wrong public key or any modification of
11 the signature would have the consequence that the decrypted signature 27 is
12 different from the signature 26 and, thus, from the message digest 28. The
13 other checks correspond to the ones described in connection with Fig. 2 and
14 need not be repeated here. If the results of all checks are satisfactory, the
15 requested switch user is initiated.

16 The purpose of the inclusion of the data "name of the server" in the SU
17 certificates 11' and 11'' of Figs. 2 and 3 is to enable the agents to handle SU
18 requests from different management servers, each having its own private and
19 public key pair. Such an environment is also called a Manager of Manager
20 environment. Since the name of the "certificate holder" is known, the DLL
21 component 13 is able to check the certificate with the correct key and, thus, to
22 verify that the request actually comes from a valid management server. It should
23 be noted that in the embodiment of Fig. 2 the certificate 11' has to contain the
24 name of the server (also) in plaintext in order to identify the correct public key
25 needed for the decryption of the encrypted part of the certificate 11'. In
26 embodiments with only one management server, the data "name of the server"
27 can be omitted.

28 Fig. 4 shows a flow chart of a switch user method using the certificate
29 generation and checking method of Fig. 3. In step S1 a private and public key

1 pair is generated. In step S2 the private key is secretly stored in the
2 management server's secure environment, and the public key is published. The
3 steps S1 and S2 are carried out during system set-up and, optionally, also
4 periodically after the system set-up. Step S3 (and the following steps) are
5 performed when the operator requests a tool and a switch user on a managed
6 node. In step S4, the management server generates an SU document and signs
7 it with the management server's private key. The result is an SU certificate. In
8 step S5 the management server sends the SU certificate to the managed node
9 together with a call to perform the tool under the requested account. In step S6
10 the agent receives a call with the SU certificate and forwards the SU certificate
11 to the domain controller. In step S7 the domain controller verifies the signature
12 with the public key of the management server. In particular, it verifies that the
13 SU document received by the agent is authentic and has not been modified. In
14 addition, it is ascertained whether the certificate has actually been directed to
15 the correct node, whether it is still within its lifetime and whether it has not yet
16 been used before. If the answers to all these questions are positive, the domain
17 controller returns in step S8 an SU token to the managed node. In step S9, the
18 managed node performs the switch user and starts the tool, as was requested in
19 step S3. If the answer to any of the questions in step S7 is negative, the switch
20 user request is denied in step S10. After steps S9 and S10, the method is
21 prepared to perform another switch user sequence with steps S3 to S9 or S3 to
22 S7 and S10.

23 Thus, a general purpose of the preferred embodiments is to provide an
24 improved method, computer program product and system for providing a switch
25 user functionality not requiring a password in an IT-network. In particular, the
26 preferred embodiments prevent: (i) an attacker who "catches" a switch user call
27 from gaining relevant information from it, since no password is provided with the
28 call; (ii) an attacker from being able to reuse the call later, because of the
29 provided time stamp; (iii) an attacker from being able to reuse the call on a

1 different managed node, since the certificate contains the name of the managed
2 node; (iv) an attacker from generating his own call, since the certificate is
3 digitally signed by the management server and this cannot be done by somebody
4 else. Thus, the preferred embodiments provide security improvements in a
5 switch user functionality without a password.

6 All publications and existing systems mentioned in this specification are
7 herein incorporated by reference.

8 Although certain systems, methods and products constructed in
9 accordance with the teachings of the invention have been described herein, the
10 scope of coverage of this patent is not limited thereto. On the contrary, this
11 patent covers all embodiments of the teachings of the invention fairly falling
12 within the scope of the appended claims either literally or under the doctrine of
13 equivalents.

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